Development of a method of thermal-neutron capture cross section measurement by unfolding prompt gamma ray spectra

Hitoshi Sakane[1], Kazuyoshi Furutaka[1], Oleg A. Shcherbakov[1], Hideo Harada[1], Toshiyuki Fujii[2], Hajimu Yamana[2]

[1] *Japan Nuclear Cycle Development Institute*
[2] *Research Reactor Institute, Kyoto University*

For the transmutation study of radioactive wastes, it is important to obtain precise thermal neutron capture cross sections of long-lived fission products and minor actinides. However, the capture cross sections for some nuclides, have not yet been measured or are poor in accuracy, because they can not be measured by conventional activation methods. Therefore, we have started the development of a method of thermal-neutron capture cross section measurement by unfolding prompt gamma ray spectra. The cross sections are determined on the basis of energy equivalence between Q-value and an energy sum of cascading gamma rays per a neutron capture reaction. However, prompt gamma ray spectra of isotopes in the medium and heavy mass region, measured with Ge detector, tend to be very complex due to high level densities of compound states. To minimize the error in the unfolding process, a pair-spectrometer system was developed to obtain high peak-to-total spectrum, in which double escape peaks and no compton distribution were clearly enhanced.

In this work, thermal neutron capture cross sections of ^{14}N and ^{27}Al were determined by unfolding prompt gamma ray spectra in order to confirm the effectiveness of these methods.

The measurements were carried out using the thermal-neutron guide tube facility in Kyoto University Research Reactor Institute. The neutron flux was about $2*10^7$ n/cm^2/s. The pair-spectrometer system, which consists of an n-type Germanium detector and a BGO annulus which is divided into two halves, was used to measure the prompt gamma rays. To estimate and subtract the contribution of background gamma rays generated by scattering neutrons, carbon foils were used. The neutron flux at the sample position was measured by detecting decay gamma rays emitted from ^{28}Al produced in the ^{27}Al(n,γ) reaction. The prompt gamma-ray spectra were obtained in singles, compton suppression and pair-spectrometer modes. To deduce the sum of gamma-ray energies from a raw spectrum of gamma rays, response functions of the detector to gamma rays up to about 10 MeV were calculated by an EGS-4 code. The cross sections of ^{14}N and ^{27}Al were determined by deducing the sum of gamma ray energies from unfolded spectra in compton suppression and pair-spectrometer modes. By comparing the present results with evaluated data in JENDL 3.3, the effectiveness of the present method was confirmed.

Email: sakane.hitoshi@jnc.go.jp